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Office of Energy Efficiency and Renewable Energy
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Building Occupant Agent

Nicholas Long, Jennifer Scheib, Kyle Benne, and Marjorie Schott

ABSTRACT

Building occupants can play an active role in reducing energy use. As the efficiency of building technologies increases the occupants' roles will become increasingly important. The Research Support Facility (RSF) creates a unique opportunity for NREL researchers to better understand how previously proven demand response techniques might be applied at the building scale. This project proposes to create virtual and physical "agents" that act as interfaces between occupants and building automation systems (BAS). The agents will convey information about lighting, miscellaneous electric loads, and natural ventilation status (open/close windows); and seek to actively understand occupant behavior and preferences to achieve positive energy outcomes.

OVERVIEW

The Building Occupant Agent (BOA) enables occupants to interact with their built environment in ways that will increase satisfaction and lower energy use.

Outcomes:

- Better knowledge about occupant comfort
- A tool to inform building engineers about necessary adjustments
- Energy savings
- Potentially better control strategies and lessons learned.

Improved control strategies:

- Completely automatic control with no occupant interaction
- Partially automated control with some occupant interaction
- Completely occupant-driven control.

BACKGROUND

Previous research on influencing occupant behavior found the following measures successful:

- Encourage action with persuasive feedback that is ambient, engaging, aesthetic, and metaphorical.
- Provide norms, commitments, communications, prompts, and incentives to influence behavioral choices.
- Incorporate real-time feedback with customizable visualization.

Fill research gap identified by Froehlich (2009) showing impactful data visualization on energy savings in long term, real-life settings.

The risks identified in the literature relate to apathy created by lack of feedback to the occupant and difficultly in installing the energy information system (EIS). These risks are being addressed early in the project.

PHASE 1

- Deploy workstation sensor kit and first phase of the client-server BOA to one participating area in the RSF.
- Develop administrative views for diagnostics.
- Identify and correct bugs or other issues.

PHASE 2

- Install workstation sensor kit to all participating areas and the first phase of the client-server BOA to all RSF occupants.
- The baseline survey needs to be building wide to meet compliance standards of Leadership in Energy and Environmental Design [LEED] developed by the U.S. Green Building Council.
- Collect and provide survey results to NREL's Sustainability Group.
- Deploy the second-phase of the client-server BOA to all participating areas.

Architecture

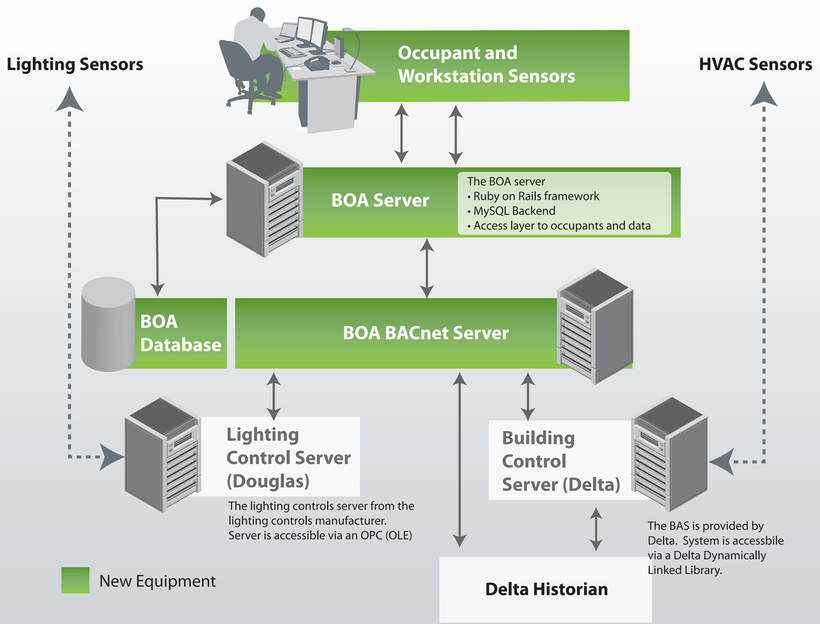


Illustration credit: istockphoto and Marjorie Schott, NREL

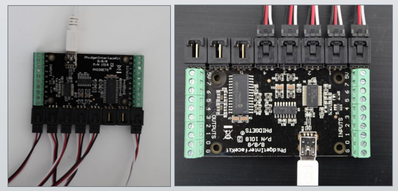
Physical Interface

LIghting

The Phidget light sensor is being calibrated to meet National Institute of Standards and Technology standards. Estimates have a +/- 10% error, which is sufficient for relative illuminance comparisons.

Credits for Photographs above: PIX/NREL 19226 and 19225 Jennifer Scheib, NREL

Workstation



Phidgets power several input and output signals through a USB port. The setup has the ability to control desktop BOAs in a later stage of this project.

Credits for Photographs above: PIX/NREL 19233 and 19232 Jennifer Scheib, NREL

Virtual Interface

Area 1 Control

Determine baseline for occupant comfort and identify barriers to saving energy. Collect LEED survey results.

Areas 2, 3, and 4

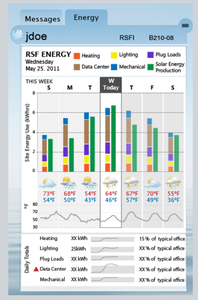
NREL's Sustainability and Commercial Buildings Groups developed a LEED occupant survey for deployment in the BOA application. The BOA will include this one-time baseline LEED survey and a continuously available comfort drop box.

The interface images are **mockup** versions of the application.

Credits: Marjorie Schott (NREL) for mockups and Nick Long, NREL/PIX19235 girl with fish, and unhappy baby photo by Larry Brackney, NREL/PIX 19236

Area 2

Building performance graphs and weather information provided to occupants.



Area 3

Empathetic display and simple energy gauge to show energy use relative to energy goal.

The user can load his or her personal photographs for the **good** and **bad** energy use images.

Area 4

Area energy use and occupant comfort display relative to other areas.

MILESTONES

Accomplished

- Workstation sensor kit parts (Phidget) selected and under testing.
- Preliminary development of BOA application to request basic feedback from the occupant.
- BOA Server and BOA BACnet Server collecting and storing preliminary occupant feedback and workstation environmental conditions.
- Initial comfort survey questions reviewed internally and under review by the U. S. Department of Energy, Protection of Human Research Subjects group.

Near Term

- Deploy BOA Server and BOA BACnet Server in NREL's data center, including website and database.
- Install Douglas and Delta OPC connections on the BOA BACnet Server to allow the lighting control system and BAS to take actions.
- Purchase remainder of Phidget interface board and sensors necessary to monitor 60 workstations.
- Improve client-server BOA interface based on the mockups.
- Obtain approval from NREL managers for select wing (group) participation.
- Distribute the first-phase interface that contains the baseline survey and simple feedback questions in the form of the second version of the window BOA.
- Identify specific Cooperative Research and Development Agreement (CRADA) opportunities for the second-phase client-server BOA interface development.
- Coordinate with RSF main display project.

FUTURE PHASES

Investigate client-server BOA deployment and BAS actuation from the BOA server. Occupant polls can be used to change an area's lighting, heating, and cooling systems to address immediate feedback.

Explore quick feedback options for groups, such as a color-changing orb. The building could provide feedback on group behavoir; e.g.,the building wants the lights off.

Illustration: Marjorie Schott, NREL

SUCCESSFUL OUTCOMES

This project will be considered successful when measurements indicate:

- Reduced energy consumption
- Increased occupant satisfaction
- Positive interaction with lighting and HVAC systems
- Continued use of BOAs.

COMMERCIALIZATION POTENTIAL

- Interface design for building engineers to address drift of building performance.
- Interface design for client-server BOA, which can save energy through changed occupant behavior.
- Intellectual property related to EIS implementation (e.g., BOA server and sensors communication framework, algorithms to control building systems based on occupant and environmental data, and methods to predict daily energy goals).